acids exhibit diurnal and seasonal variations. Photochemical oxidation processes have been postulated to produce acids in the gas phase, but emissions from plants also contribute, in addition to anthropogenic sources such as vehicular emissions and biomass burning. Biogenic pathways for the production of organic acids are well known, the problem appears to be the release mechanism.

There can be no doubt that biogenic emissions contribute significantly to the total amount of volatile organic compounds in the atmosphere. As the book makes clear, our knowledge and understanding of such emissions is still unsatisfactory despite much progress in recent years. Improvements are needed in measurement technologies, in the identification of compounds being emitted, in the biosynthetic pathways and release mechanisms, and in atmospheric chemical processes. The book provides essential information to anybody intending to venture into the difficult subject of biogenic emissions of volatile organic compounds; and, at the same time, it provides a comprehensive summary to researchers in this field. The book also contains a rather complete list of the relevant literature, and for all these reasons it can be fully recommended.

Mainz, Germany PETER WARNECK

Sir John Houghton: *Global Warming: The Complete Briefing*, 2nd edition, Cambridge University Press, hardback ISBN 0-521-62089-9, £35.00; paperback ISBN 0-521-62932-2, £12.95

I have mixed feelings about Global Warming: The Complete Briefing. On the one hand John Houghton has done a splendid job of presenting the broad and complex global warming story at a level that can be appreciated by the educated lay person, teacher or student. For this reason my overall conclusion is that the book has considerable potential value for students and general readers, and I hope that it will receive the widest possible distribution.

My reservations arise not from the book's slight flavor of condescension (epitomized by the title). Rather I am concerned by its moralistic aspect, which I believe to be unhelpful to understanding of how science research works and to appreciation of the beauty and integrity of unbiased scientific investigation. But I believe that the merits of the exposition far outweigh any deficiencies, and I would be glad if others conclude that my reservations are insignificant caviling.

The book begins with tutorials on global warming, the greenhouse effect and the Earth's carbon cycle. It has a brief but useful discussion of climate data and inferred climate changes of the past. There are longer descriptions of climate models, climate simulations and potential impacts of climate change. I particularly appreciate the space devoted in the latter half of the book to uncertainties in the global warming story as well as the discussion of actions that can be taken in the

face of uncertainty, actions that would slow global warming and that make good common sense in any case.

Houghton places in the middle of the book a chapter 'Why Should We Be Concerned' that addresses the responsibility of humans to look after the Earth's environment. It seems to me not only that he has the right to express his personal values and describe his motivations as a Christian, but that it enriches the discussion for all readers. However, I am troubled by the degree to which he mixes and, I believe, eventually confuses ethical and scientific issues. It results in pure scientific inquiry being denigrated as something 'pursued with a clinical detachment and without thinking about the ethical consequences'.

Houghton quotes Albert Einstein as saying 'The most incomprehensivle thing about the universe is that it is comprehensible' and Houghton connects this with a responsibility of scientists to be stewards of the Earth. We can all agree on the need for environmental responsibility, and even relish the prospect that our research might contribute to environmental well being. But I believe that Einstein's statement is more a marveling at the fact that it is possible, at least to a degree, to figure out how the world works. This marvel, and the implied fun and excitement in research, drives scientists in their pursuit of understanding. The essence and the beauty of iterative scientific inquiry is its logic and objectivity, and its success depends upon open-minded unbiased interpretation of each new piece of data.

Injection of environmental and political perspectives in midstream of the science discussion cannot help the process of inquiry. I believe that persons with relevant scientific expertise should concentrate, with pride, on cool objective analysis, providing information to the public and decision-makers when it is found, but leaving the moral implications for later common consideration, or at most for summary inferential discussion. I am not implying bias on the part of any particular scientist. But the global warming debate has plentiful examples to illustrate my thesis, especially, at least on a per capita basis, among the most vociferous greenhouse 'skeptics', i.e., those who challenge the reality or interpretation of global warming. Many of the participants in this debate have ceased to act as scientists as defined above, but rather act as if they were lawyers hired to defend a particular perspective. New evidence has no effect on their preordained conclusions. This is abhorrent to science and spoils the fun of it.

My remaining comments concern details of the presentation. A venial flaw is the apparent misunderstanding that the greenhouse effect on Earth is a chance result of the decrease of temperature with height in the troposphere. On the contrary, the decreasing temperature is a consequence of the greenhouse effect as radiation attempts to remove heat from the surface. Heat carried by atmospheric motions, including effects of water vapor, can limit the rate of temperature decrease with height, but it cannot change the sign of the gradient.

Two aspects of the presentation that I particularly liked and wished for further elaboration were discussion of the climate on Mars and the role of chaos in climate variations on Earth. Comparison of the surface temperatures of Mars and

Venus, with their lesser and greater greenhouse effects than that on Earth, provides a nice test of our understanding of the greenhouse mechanism, which Houghton utilizes. It would be worthwhile to also note the spectacular climate changes that have occurred on Mars, as evidenced by the dried up river valleys discovered by spacecraft, and to discuss the possible value of understanding the nature and causes of these climate changes. Similarly, there is great potential value in a better popular discussion of chaotic climate variability. If the public develops a good appreciation of natural climate variability that may help avoid misinterpretation of future climate fluctuations.

Despite Hougton's attention to scientific uncertainty, as mentioned above, there are several cases where the impression is left that our understanding is much more pat than it really is. A good example is methane, which accounts for about 20 percent of the anthropogenic greenhouse effect. Houghton assumes that methane growth is closely tied to population, and thus the scenarios that he illustrates have large methane growth in the next century. But in the last few years methane growth has fallen to no more than a quarter of the value of previous decades. Why has the growth rate of methane plummeted? Will it accelerate again, or is it possible that we could take steps to make its growth negative, thus balancing some of the carbon dioxide warming? I believe that the range of uncertainty encompasses both possibilities. Our ignorance of the balance of factors affecting methane makes prediction of future trends very unreliable.

Another example is future sea level change. Houghton includes, appropriately, caveats about the difficulty of predicting future sea level. Yet I suspect that actual uncertainties are much larger. In the principal scenario that he considers, which has an atmospheric carbon dioxide amount of over 700 parts per million by 2100, Antarctica and Greenland together contribute only 5 cm to increased sea level by 2100, as ice sheet growth due to increased snowfall approximately balances increased ice sheet melting. But we do not understand well the processes that affect ice sheet changes. For example, if carbon dioxide does reach 700 ppm, global warming might be sufficient to cause occasional heavy warm summer rains over parts of the ice sheets. Empirical evidence from the paleoclimate record reveals cases when ice sheets disintegrated at rates causing sea level rise of 1–2 meters per century or more. Certainly processes exist that can cause ice sheet disintegration more rapid than 5 cm per century.

These are but a few of the many uncertainties that affect climate projections for the next century. A curious thing is that, despite the emergence of climate change as a topic of global strategic importance, support for the fundamental research needed to develop quantitative understanding has not increased markedly. It would have been good if Houghton had used the soapbox which his book provides to issue a clarion call for the research support required to reduce the scientific uncertainties

and uncover the scientific surprises that undoubtedly remain. Still, the book has much of interest to students and researchers, and I hope that it will be widely read.

NASA Goddard Institute for Space Studies, JAMES E. HANSEN
New York City,
U.S.A.

Egbert K. Duursma and JoLynn Carroll: *Environmental Compartments, Equilibria and Assessment of Processes Between Air, Water, Sediments and Biota*, Springer-Verlag, Berlin, 1996, 277 pages (+ 3.5″ diskette), hardback ISBN 3-540-61039-1, DM 98,–.

The book under review consists of an introduction and nine chapters entitled as follows: Processes and equilibria between compartments, Complexing metal- and radionuclide-sediment reactions, Diffusion principles, Organochlorines, Competitive reactions and effects of conservativity, Examples of distribution patterns in estuaries and seas, Nuclear waste in the Kara Sea, Global oceanic and atmospheric stability of oxygen and Case studies on Environmental Impact Assessment (EIA). In appendix I the answers to eleven exercises incorporated in the chapters are presented. Appendix II describes a box model of radionuclide transport from dumped nuclear waste in the Kara Sea, written by J. Carroll in FORTRAN. The program files for this model and a demo version of a commercially available program named COSMO-BIO are provided on a 3.5″ diskette attached to the book. COSMO-BIO runs under MS-Windows and was designed to illustrate the role of biodiversity in coastal management.

In the preface E. K. Duursma and J. Carroll define the scope of their book: ‘How are phenomena, even of a small scale, correlated to large-scale processes we observe in different compartments of our global environment?’ This question is the fundamental driving force for actual and rapidly developing research fields such as global change or biogeochemical cycles. Moreover, the authors intend to present ‘basic information on theories and measurements on the distribution of substances between air, water, sediments and biota’. Cases studies on organochlorines (DDT, PCB), metals and radionuclides are used to illustrate basic principles of processes and equilibria in oceanic environments (i.e., mainly estuaries and coastal areas). However, interactions between the air and water compartments seem to play a negligible role. For example, an important process such as gas transfer across the water – atmosphere interface is ignored. Nevertheless, the authors dedicate parts of chapter 9 to the global CO_2 cycle without taking into account, however, that an understanding of the problems involved with the cycling of gases between ocean and atmosphere requires some more detailed information about air–sea gas exchange processes. Additionally, I would like to have seen a chapter devoted to the laws